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The purpose of this project was to manufacture women's shirts for fit and performance testing by the U.S. Army. Patterns were received from the Navy, Air Force, and Coast Guard by way of US Army Natick and arrived in the form of ozalids and computer files. Two shirt styles were to be produced, #1 with Air Force styling and Air Force Collar, #2 with Navy styling, Air Force collar, and Coast Guard pocket. Due to multiple inconsistency and inaccuracy problems with the patterns, it was resolved that the Navy body would be used as the foundation for the two styles. Accurate, consistency graded patterns were created for the two styles, and, following the approval of additional prototypes, 48 shirts were produced. Detailed garment dimension specification charts were provided for future quality control. Recommendations were made for modifications to enhance producibility. Following a fit test, modifications to the patterns were made by Natick and 880 shirts for wear test were produced. During the course of the project, problems related to the inappropriate use of CAR technology, typical of the industry at large, surfaced and were addressed.

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Research Women's Shirt Production

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**Clemson Apparel Research
DLA900-87-D-0017 DO 0023**

by

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PRODUCTION FOR FIT TEST

Receipt of Patterns

The project to manufacture sample women's shirts for fit and performance testing by the US Army was begun in early March 1991 with the arrival of patterns at CAR from Natick. Shirt #1 arrived as ozalids of the US Navy women's shirts in sizes 32 through 42 with neck sizes 12 through 16 and sleeve lengths 29, 30, 32, and 34. The graded Coast Guard pocket pattern and a dimensionally adapted version for the Army were also provided. Shirt #2, the Air Force women's shirt in 17 odd and even sizes from 6 to 22 with regular and plus bust sizes (spec difference 3/4 inch) and short, regular, and long sleeve lengths for each size, with the neckline adapted to receive the Air Force women's banded collar, was received as Microdynamics computer files of the sample size 10 and an accompanying grade rule table.

Analysis of Patterns

An analysis of the patterns revealed that there were multiple problems. Shirt #1 was erroneously graded such that the cross shoulder width grew with each increasing neck size for a given bust size (See Appendix A). This resulted in a difference of 1-3/4 inches of cross shoulder width for the range of a size 12 neck to a size 15 neck with a 34 bust. Due to the difficulties associated with trying to adapt this grading to the Air Force neckline, it was decided by Martha McCagg to leave the Navy neckline and attach an Air Force collar of compatible neck length for the Shirt #1 prototypes. The Coast Guard pocket grading was eliminated and one size pocket was used on all sizes. The pocket pattern provided had to be increased in width by one inch in order to achieve the required finished dimensions. Three shirts were thus produced in sizes 32/12/32, 36/14/30, and 40/16/34 (bust/neck/sleeve).

Shirt #2 was riddled with problems. The patterns had been input as graded nests. This technique, if not "cleaned up" after input, results in excessive numbers of grade rules with inconsistent grade increments. It allows the computer to determine grade increments between sizes based on the input in every size of each grade point on the perimeter of the pattern. Since the rules are written in ten-thousandths of an inch, even minute differences are picked up by the computer as separate rules. The fact that the regular and plus bust sizes had been input with the necks in opposite directions only complicated matters further. Pattern pieces which should have been symmetrical were not. Necklines which should have been the same shape were not. Sleeve lengths were digitized separately instead of as grade rule variations to the same sleeve. The side front was graded in such

a way that the princess seam over the bust had the identical curve for all 17 sizes. Pieces which should have had seams conforming to the x or y axis were skewed. Upon examination it was discovered that the bust of the center back regular size was larger than that of the plus size (see Appendix B) and that the cuff was too small for the sleeve. As a result of these problems, Barbara Quinn provided a revised Shirt #2 computer file which applied the Army grade rules to the Air Force shirt. Authorization was given by Martha McCagg to improve the precision of the pattern pieces such that parts fit each other and that the plus sizes were in fact 3/4 inch larger in the bust than the regular sizes. Three shirts were produced in sizes 6 short, 14 regular, and 22+ long.

COTR Review and Resulting Modifications

On March 28 and 29, Martha McCagg and Captain Kathleen Batton met with the PI at CAR to inspect the pre-production shirt prototypes. The problems associated with each shirt were discussed, as well as the potential volume of uncontrollable variables prone to error in assessing fit based on these two shirts. It was resolved that the shirts for fit test would be limited to the use of the Navy shirt body. Anthropologists Ken Parham and Helen Belaources would provide biacromial breadths, intercyce breadths, and neck to apex measurements from which the erroneous shoulder grade could be corrected for both shirts and the Shirt #2 could be remade using the Navy body with Air Force styling. For each bust size, all shirts would use the Air Force neckline and collar in two sizes (small and large) plus two of four available sleeve lengths (A=29, B=30, C=31, D=32), each with double buttons for adjustable fit. Following the receipt of the necessary data in early April, six additional prototype shirts were produced, Shirt #1 with Navy styling and Coast Guard pockets in sizes 32SB, 36SC, and 40SD and Shirt #2 with Air Force styling in sizes 32LB, 36LC, and 40LD.

It should be noted here that the anthropologists were unable to provide the measurements necessary to confirm a cross shoulder width that would conform to current anthropometric data. The nearest measurement available was an Intercye II, the distance between the top of the axilla fold on each side of the body across the back. The biacromial breadth was not among those recorded by the anthropologists, in spite of the fact that the cross shoulder measurement is critical for patternmaking and quality control in the manufacture of tops. As a result, the most logical-seeming cross shoulder width of the four in the Navy size 34 sample size was selected as the foundation for the re-styled pattern.

Manually-traced patterns on the US Navy ozalid were evaluated for precision by nesting individual pattern pieces in the full range of sizes. By this means, the intended grade rules were determined and inconsistencies inherent in manual transfer were identified. To avoid the possibility of any graded size being too small, since the bust grade, for example, was not consistent between sizes, the smallest size (32) was used as the sample size

to be input into the computer and to which grade rules were applied. After the pattern pieces had been digitized, the seam allowances were removed and all pieces were "cleaned up" to insure a precise fit in garment construction. The line lengths and shapes of all seams on all pattern pieces that would be sewn together in manufacturing were checked to insure precise fit (the computer quickly and easily displays line lengths and pattern pieces can be manipulated to lock together on seams of the same shape or to "walk" automatically to check the relationship of curves to each other). The Air Force neckline was transferred to the Navy body to create small and large neck sizes for each bust size. Grade rules were written to accomplish the specified neck size changes. Graded nests were checked for line lengths in all sizes on coordinating pattern pieces and grade rules were adjusted where necessary. Only after all pattern pieces in all sizes had been determined to be correct, and measurements had been recorded, were the seam allowances added back, the markers prepared, and the shirts cut and assembled.

The specified shirts, with an accompanying detailed garment dimension specifications chart (see Appendix C), were delivered to the COTR on April 26, 1991. The specifications chart included half bust, half sweep, cross shoulder, oversleeve, undersleeve, half bicep, half cuff (buttoned) center back length, and collar circumference, representing actual pattern dimensions measured by the computer and recorded in three decimal places. The prototypes as constructed were approved by the COTR.

Production and Distribution of Fit Test Garments

Authorization was obtained on May 28 to produce one of each style shirt in each of six bust sizes, two neck sizes, and two sleeve lengths for a total of 48 shirts. Production was begun May 29. The shirts were measured and approved at a COTR inspection on June 7 prior to fit test June 10 through July 3.

Following suggestions made by the plant operators, pattern modifications were made to improve the sewability of the shirts. These included making the seam allowance of all seams to be safety stitched $\frac{3}{8}$ inch (to facilitate finishing precisely at $\frac{1}{4}$ inch), increasing the seam allowance on the pockets to $\frac{1}{2}$ inch (to facilitate creasing), and slightly adjusting the radius of the curve on the cuff (to be compatible with automatic cuff running, turning, and topstitching equipment).

The principal investigator assisted at the fit test of shirts, skirts, and pants in Alexandria, Virginia on June 17 and 18. Observations were made and suggestions given for modifying some construction features to make the uniform components inherently more alterable. This included a rather unconventional sequence of operations for a princess-to-the-shoulder, three-piece-back shirt. It was suggested that if the side panels were joined at the shoulder, and the center panels joined at the shoulder, followed by the

princess seam being joined from back hem to front hem, a shoulder narrowing alteration could easily be made to this safety stitched seam without having to rip out any stitches. A similar suggestion was made for the attachment of the skirt waistband at the side seams.

PRODUCTION FOR WEAR TEST

Receipt of Patterns and First Article Approval

Following the fit test in June, during the months of July through October the project was on hold, awaiting the beginning of Phase 2, manufacturing shirts for the wear test. Meanwhile, during the month of September a sample necktab was received from Natick, digitized, and returned in preparation for possible production of this revised necktab for wear test.

During the month of November the project continued with the receipt of revised patterns, sample garments, and instructions for the production of Class 1 and 2 tuck-in first articles. The two shirts for the tuck-in first article were produced. During the month of December the project continued with the receipt of patterns, sample garments, and instructions for the production of Class 1 and 2 overblouse first articles. The two shirts for the overblouse first article were produced and on December 10 the principal investigator went to Natick for the approval of all four first articles by the COTR. A list of the numbers of garments in each of the fifty-six sizes to be produced was received, and authorization to begin production was given (pending the installation of a new numerically controlled cutter at CAR). An error in the coordination of sizes between non-proportional tuck-ins and proportional overblouses was corrected by the COTR. The garment dimensions chart provided for quality control included half bust, half sweep, center back length, sleeve length, and collar circumference.

Observations of Methods and Procedures at Natick

During the visit to Natick, the procedure for producing samples and first patterns and the work flow through digitizing, grading, and pattern cutting were discussed. The principal investigator sought to determine the source of inaccuracy in the patterns coming out of Natick. Fit test patterns sent to Natick in Spring/Summer 1991 had been checked, without seam allowances, to insure that all pattern pieces fit together. In addition, graded nests had been measured to insure that grade rules had been correctly written such that all pattern pieces would fit together in all sizes. The modified patterns received from Natick in November and December 1991 did not reflect this precision.

Because it had been assumed that the patterns received were as precise as those sent earlier in the year, in preparation for the assembly of the first article shirts, the principal investigator had only adjusted the seam allowance depth (to permit more accurate safety stitched seams), then made markers, had the pieces cut, and authorized the assembly of the parts without checking pattern precision. The principal investigator was first alerted to potential problems when a sewing machine operator pointed out her difficulty in attaching the collar band to the collar of the first article tuck-in. The collar band was too long for the collar and the notches did not match.

Upon investigating the problem (by calling up the pattern pieces on the computer, stripping the seam allowances, and walking the pattern pieces) it was determined that the collar band was 3/8" longer than the collar edge to which it was to be attached and the notches were out of alignment by nearly 1/4" (see Appendix D). Further investigation determined that the grade rules applied to corresponding points on the collar band and collar resulted in collars that would could not meet the specs provided and, even if the sample size collar were adjusted to fit the collar band, the collar and collar band would not fit each other in all sizes (see Appendix E). In addition, there were duplicate rules in each rule table, rule tables already inflated in size due to the assumed inability of Natick's cardboard pattern cutting device to read mirrored pieces and opposite rules (Microdynamics later confirmed that the cardboard cutting device receives all data as x,y coordinates and therefore CAN read mirrored pieces and opposite rules).

During the visit to Natick it was discovered that the procedure used encouraged the inaccuracy encountered in this project. Although Microdynamics computer equipment is employed for digitizing and grading of pattern pieces, first patterns are still made manually and transferred by digitizing the cut lines. The resulting patterns are never "cleaned up" to insure that all pieces will fit precisely. Because seam allowances are not removed, graded pattern pieces cannot be determined to fit properly in all sizes. The erroneously assumed constraints of the pattern cutting device causes excessive numbers of grade rules. It is unfortunate that the method of operation at Natick does not permit using the investment in Microdynamics CAD equipment to a greater level of its capability.

Production and Distribution of Wear Test Garments

Following the visit to Natick, corrections involving improving precision, but not modifying garment design, were authorized by the COTR. The patterns were "cleaned up" and during the month of January the production of the shirts for wear test was begun. As an aid to keeping all the sizes straight, each ply of cloth cut included one of each shirt in the same size (four shirts per marker). A chart developed for all the cuts (see Appendix F) aided the marker maker, cutter, and plant manager to coordinate the work. The first delivery, the long-sleeve tuck-in shirts, was sent on February 18. This included 220 each of a shirt with pockets and a shirt without pockets (see Appendix G). The overblouses were shipped March 4. This included 220 each of a long-sleeved and a short-sleeved overblouse without pockets (see Appendix I). The principal investigator went to Alexandria, VA on February 27 to observe the distribution of uniforms for wear test.

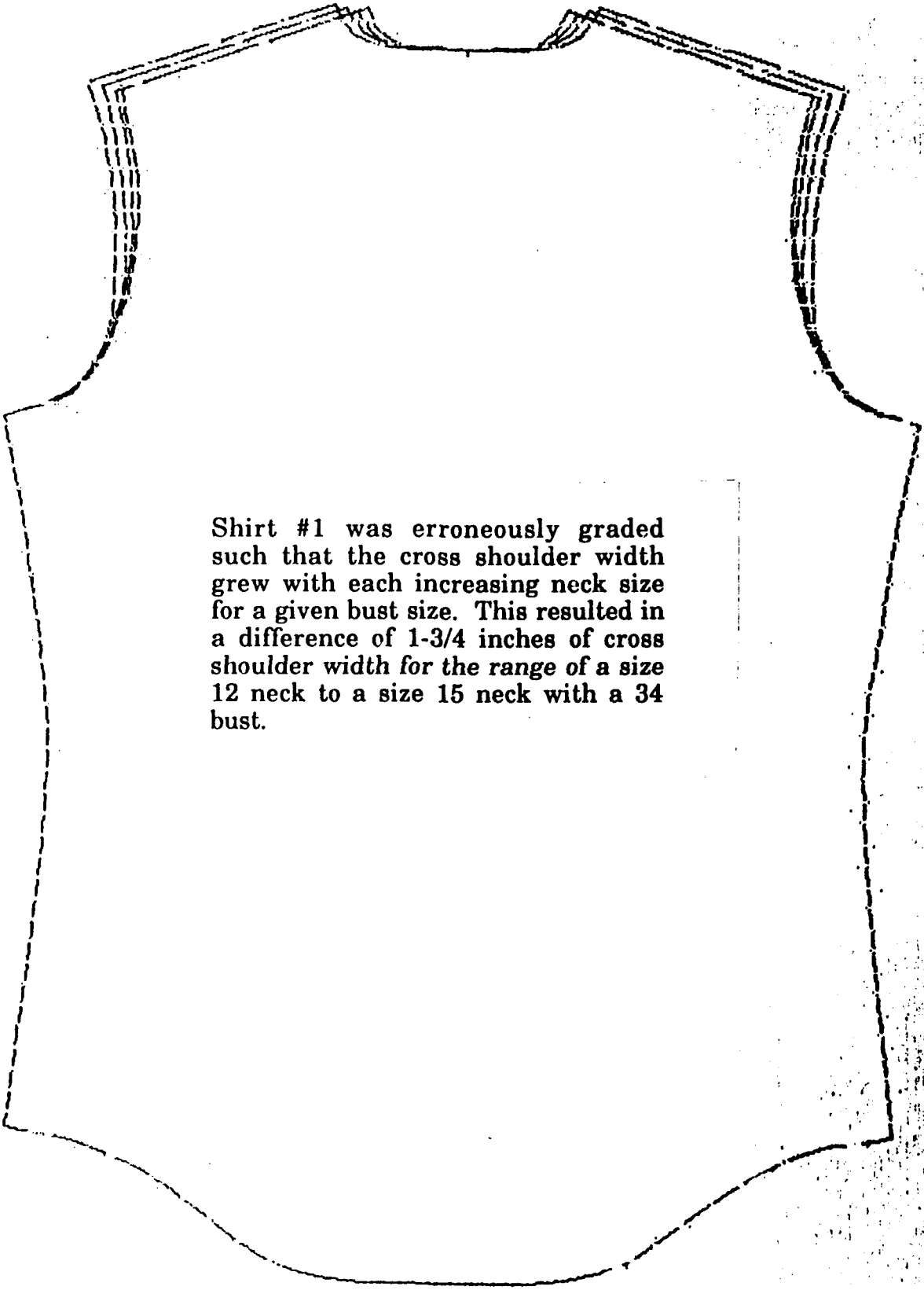
FINAL OBSERVATIONS

Although the intent of this project was originally simply to manufacture sample women's shirts for fit and performance testing by the US Army, by necessity it additionally evolved into a comprehensive analysis of military patterns and patternmaking procedures. The PI believed that there was no sense in producing, for fit or wear test, garments which were inherently imprecise due to pattern problems. The resulting discoveries pointed out numerous ways in which the available technology could be used to produce more precise and more consistent uniforms by insuring that the patterns distributed from Natick are the best that they can be.

Lest it be assumed that the personnel at Natick are at fault for the quality of product they provide, in spite of their access to technology, it should be pointed out that they are not alone in the problems this project identified. The apparel industry as a whole has either: 1) not embraced currently available technology to help it do a better job, or 2) not followed capital investment in technology with a change in methods and procedures to exploit fully the benefits of the technology. When CAD equipment is purchased, the CAD vendor provides instruction on the use of the equipment, how to use the vendor's software to perform specific tasks. The trainer does not, however, have time, nor does the vendor necessarily have the responsibility during initial training, to provide additional instruction

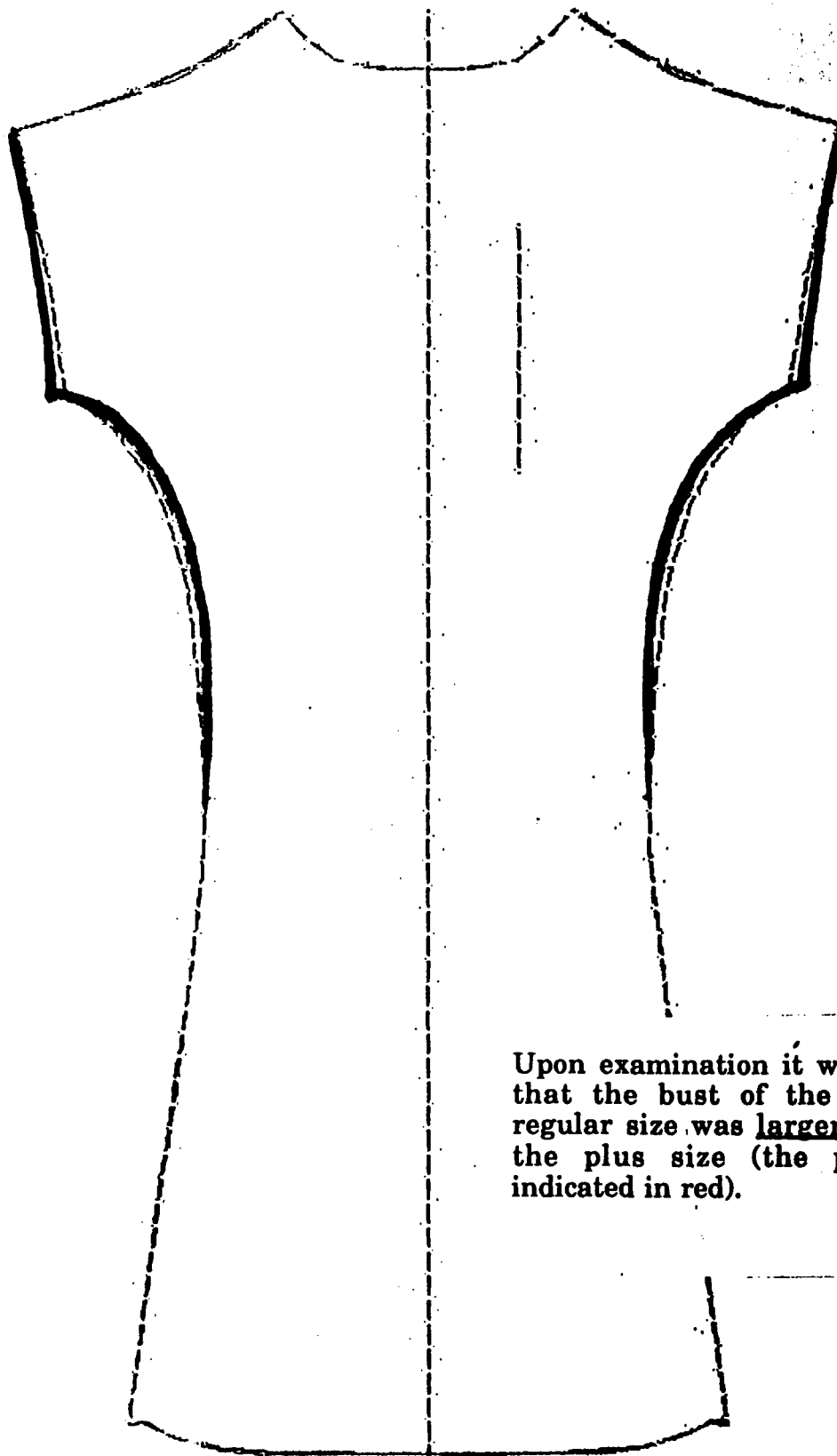
in how to change from a manual mode of organizing work to a computer-aided mode, including allowing the computer to perform tasks that were either impractical, or not even possible manually. During the initial training the focus is on learning to use the tool, and rightly so. Unfortunately no one has yet formally addressed the question of when, by whom, and at whose expense training to adjust methods of operation employing CAD technology should occur. Since it is the mission of the AAMTD's to encourage the proper application of advanced technology, it is only fitting that the raising of these issues should emanate from Clemson Apparel Research.

Appendix A



Shirt #1 was erroneously graded such that the cross shoulder width grew with each increasing neck size for a given bust size. This resulted in a difference of 1-3/4 inches of cross shoulder width for the range of a size 12 neck to a size 15 neck with a 34 bust.

Appendix B



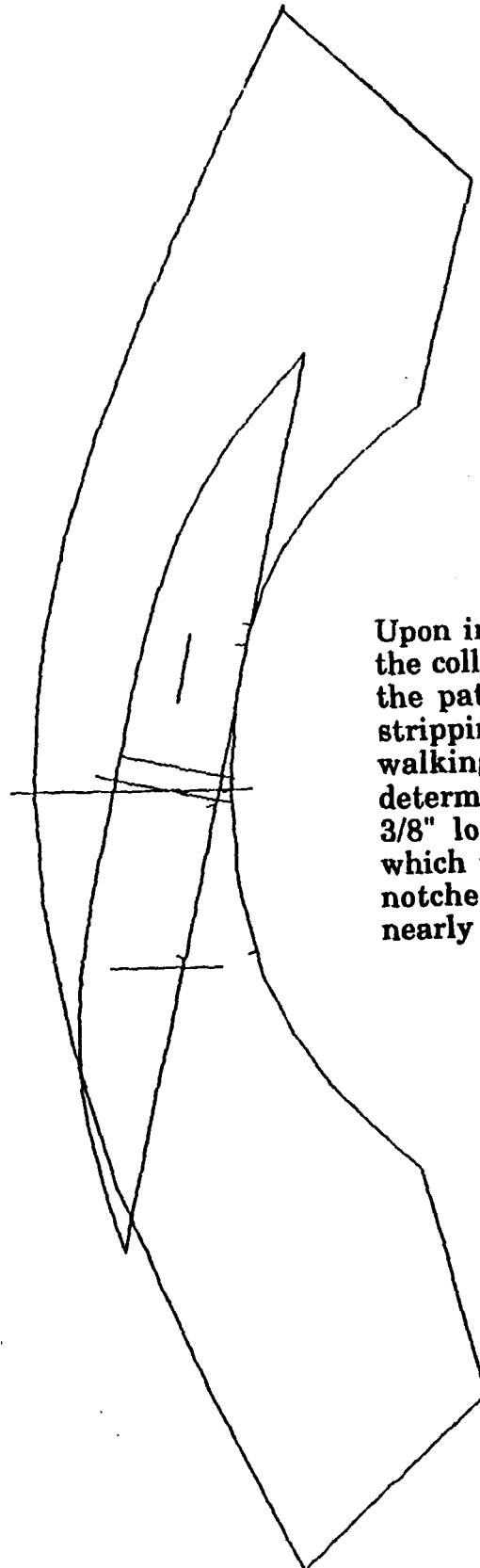
Upon examination it was discovered that the bust of the center back regular size was larger than that of the plus size (the plus size is indicated in red).

Appendix C

GARMENT DIMENSION SPECIFICATIONS

SIZE	32	34	36	38	40	42			
1/2 BUST	19.526	20.526	21.526	22.526	23.526	24.526			
1/2 SWEEP #1	19.405	20.405	21.405	22.405	23.405	24.405			
1/2 SWEEP #2	20.231	21.231	22.231	23.231	24.231	25.231			
CROSS SHOULDER	15.384	15.764	16.144	16.504	16.884	17.264			
OVERSLEEVE	23.373	23.558	23.823	24.069	24.325	24.581			
B	24.373	24.558	24.823	25.069	25.325	25.581			
C	25.373	25.558	25.823	26.069	26.325	26.581			
D	26.373	26.558	26.823	27.069	27.325	27.581			
UNDERSLEEVE	ALL SIZES	A=18	B=19	C=20	D=21				
1/2 BICEP	6.80	7.141	7.49	7.83	8.18	8.52			
1/2 CUFF	4.819	4.949	5.069	5.199	5.319	5.449			
BACK LENGTH	27.671	27.981	28.301	28.611	28.921	29.231			
COLLAR S	14.50	14.75	15.00	15.25	15.50	15.75			
COLLAR L	15.00	15.25	15.50	15.75	16.00	16.25			

Appendix D



Upon investigating the problem with the collar and the band (by calling up the pattern pieces on the computer, stripping the seam allowances, and walking the pattern pieces), it was determined that the collar band was $\frac{3}{8}$ " longer than the collar edge to which it was to be attached and the notches were out of alignment by nearly $\frac{1}{4}$ ".

Appendix E

Women's Army Long Sleeve Tuck In Shirt
Garment Dimensions as Received 9/91

Size	Collar neck	Stand neck	Total	Intended	Difference
4	2.337	9.837	14.511	14.625	-.114
6	2.405	10.012	14.822	14.875	-.053
8	2.455	10.189	15.099	15.125	-.026
10	2.523	10.365	15.411	15.375	+.036
12	2.582	10.528	15.692	15.625	+.068
14	2.651	10.700	16.002	15.875	+.127
16	2.701	10.878	16.280	16.125	+.155
18	2.770	11.055	16.595	16.375	+.220
20	2.830	11.224	16.884	16.625	+.259

Appendix F

Name Style Size Group
SHORT

4RS	LS_TI	4S	A
5 ply	OVRBLS	4	A
#1			

SIZE 4R

6RS	LS_TI	6S	A
2 ply	OVRBLS	6	A
#3			

SIZE 6R

8RS	LS_TI	8S	A
2 ply	OVRBLS	8S	A
#7			

SIZE 8S

8RS	LS_TI	8S	A
2 ply	OVRBLS	8	A
#10			

SIZE 8R

8LS	LS_TI	8S	A
1 ply	OVRBLS	8L	A
#13			

SIZE 8L

10SS	LS_TI	10S	A
7 ply	OVRBLS	10S	A
#16			

SIZE 10S

10RS	LS_TI	10S	A
2 ply	OVRBLS	10	A
#19			

SIZE 10R

10LS	LS_TI	10S	A
1 ply	OVRBLS	10L	A
#22			

SIZE 10L

Name Style Size Group
REGULAR

4RR	LS_TI	4	A
5 ply	OVRBLS	4	A
#2			

6RR	LS_TI	6	A
10 ply	OVRBLS	6	A
#5			

8SR	LS_TI	8	A
5 ply	OVRBLS	8S	A
#8			

8RR	LS_TI	8	A
8 ply	OVRBLS	8	A
#11			

8LR	LS_TI	8	A
1 ply	OVRBLS	8L	A
#14			

10SR	LS_TI	10	A
7 ply	OVRBLS	10S	A
#17			

10RR	LS_TI	10	A
14 ply	OVRBLS	10	A
#20			

10LR	LS_TI	10	A
4 ply	OVRBLS	10L	A
#23			

Name Style Size Group
LONG

4RL	LS_TI	4L	A
1 ply	OVRBLS	4	A
#3			

6RL	LS_TI	6L	A
2 ply	OVRBLS	6	A
#6			

8SL	LS_TI	8L	A
3 ply	OVRBLS	8S	A
#9			

8RL	LS_TI	8L	A
3 ply	OVRBLS	8	A
#12			

8LL	LS_TI	8L	A
2 ply	OVRBLS	8L	A
#15			

10SL	LS_TI	10L	A
1 ply	OVRBLS	10S	A
#18			

10RL	LS_TI	10L	A
6 ply	OVRBLS	10	A
#21			

10LL	LS_TI	10L	A
4 ply	OVRBLS	10L	A
#24			

	SHORT				REGULAR				LONG			
	Name	Style	Size	Group	Name	Style	Size	Group	Name	Style	Size	Group
SIZE 12S	12SS	LS_TI	12S	A	12SR	LS_TI	12	A	12SL	LS_TI	12L	A
	1 ply	OVRBLS	12S	A	9 ply	OVRBLS	12S	A	4 ply	OVRBLS	12S	A
	#25				#26				#27			
SIZE 12R	12RS	LS_TI	12S	A	12RR	LS_TI	12	A	12RL	LS_TI	12L	A
	3 ply	OVRBLS	12	A	7 ply	OVRBLS	12	A	8 ply	OVRBLS	12	A
	#28				#29				#30			
SIZE 12L	12LS	LS_TI	12S	A	12LR	LS_TI	12	A	12LL	LS_TI	12L	A
	1 ply	OVRBLS	12L	A	1 ply	OVRBLS	12L	A	11 ply	OVRBLS	12L	A
	#31				#32				#33			
SIZE 14S	14SS	LS_TI	14S	A	14SR	LS_TI	14	A	14SL	LS_TI	14L	A
	1 ply	OVRBLS	14S	A	9 ply	OVRBLS	14S	A	2 ply	OVRBLS	14S	A
	#34				#35				#36			
SIZE 14R	14RS	LS_TI	14S	A	14RR	LS_TI	14	A	14RL	LS_TI	14L	A
	1 ply	OVRBLS	14	A	12 ply	OVRBLS	14	A	8 ply	OVRBLS	14	A
	#37				#38				#39			
SIZE 14L	14LS	LS_TI	14S	A	14LR	LS_TI	14	A	14LL	LS_TI	14L	A
	1 ply	OVRBLS	14L	A	2 ply	OVRBLS	14L	A	8 ply	OVRBLS	14L	A
	#40				#41				#42			
SIZE 16S	16SS	LS_TI	16S	A	16SR	LS_TI	16	A	16SL	LS_TI	16L	A
	10 ply	OVRBLS	16S	A	2 ply	OVRBLS	16S	A	1 ply	OVRBLS	16S	A
	#43				#44				#45			
SIZE 16R	16RS	LS_TI	16S	A	16RR	LS_TI	16	A	16RL	LS_TI	16L	A
	1 ply	OVRBLS	16	A	2 ply	OVRBLS	16	A	5 ply	OVRBLS	16	A
	#46				#47				#48			

SIZE 16L

Name	Style	Size	Group	Name	Style	Size	Group
16LS	LS_TI	16S	A	16LR	LS_TI	16	A
1 ply	OVRBLS	16L	A	3 ply	OVRBLS	16L	A
#49				#50			

SIZE 18R

Name	Style	Size	Group	Name	Style	Size	Group
18RS	LS_TI	18S	A	18RR	LS_TI	18	A
1 ply	OVRBLS	18	A	1 ply	OVRBLS	18	A
#52				#53			

SIZE 20R

Name	Style	Size	Group	Name	Style	Size	Group
20RS	LS_TI	20S	A	20RR	LS_TI	20	A
1 ply	OVRBLS	20	A	1 ply	OVRBLS	20	A
#54				#55			

SIZE 16L

Name	Style	Size	Group	Name	Style	Size	Group
16LL	LS_TI	16L	A	16LR	LS_TI	16	A
10 ply	OVRBLS	16L	A	3 ply	OVRBLS	16L	A
#51				#50			

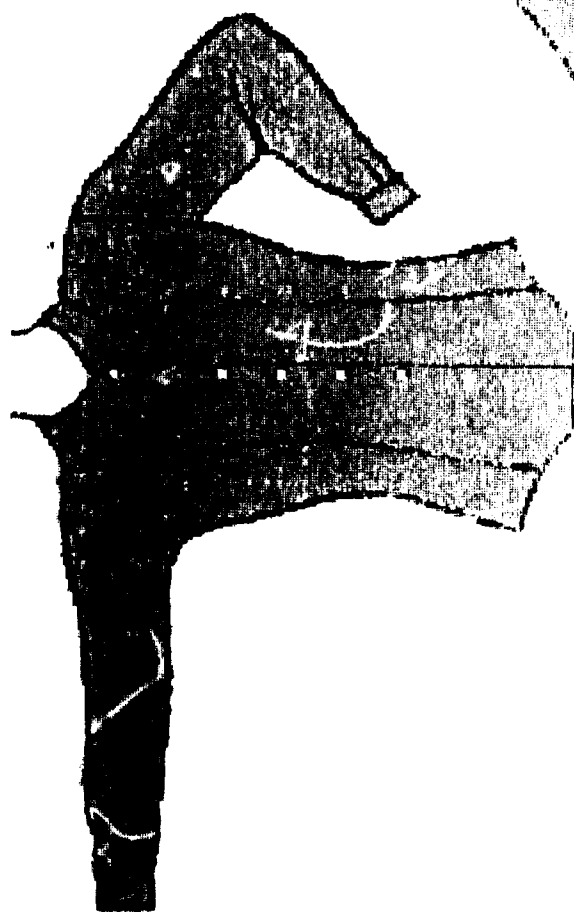
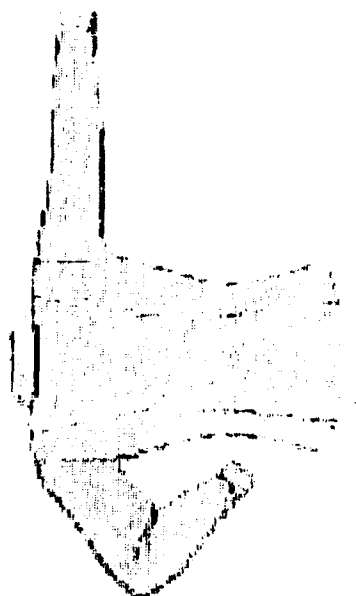
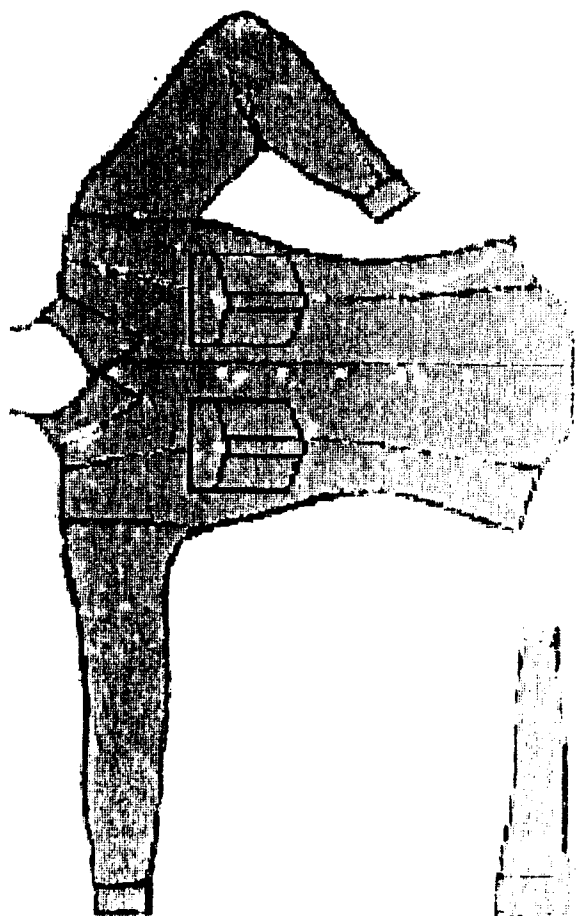
SIZE 18R

Name	Style	Size	Group	Name	Style	Size	Group
18RL	LS_TI	18L	A	18RR	LS_TI	18	A
3 ply	OVRBLS	18	A	1 ply	OVRBLS	18	A
#54				#53			

SIZE 20R

Name	Style	Size	Group	Name	Style	Size	Group
20RL	LS_TI	20L	A	20RR	LS_TI	20	A
2 ply	OVRBLS	20	A	1 ply	OVRBLS	20	A
#56				#55			

Appendix G



Appendix H

